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Sewerable Water

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Introduction

In 1998, the Livermore site discharged approximately 1 million liters (ML) per day of wastewater to the City of Livermore sewer system, an amount that constitutes 4.0% of the total flow to the system. This volume includes wastewater generated by Sandia National Laboratories California, which is discharged to the LLNL collection system and combines with LLNL sewage before it is released at a single point to the municipal collection system (**Figure 6-1**). In 1998, Sandia / California generated approximately 14% of the total effluent discharged from the Livermore site. LLNL's wastewater contains sanitary sewage and industrial wastewater and is discharged in accordance with permit requirements and the City of Livermore Municipal Code, as discussed below in the Pretreatment and Categorical Discharges sections.

The effluent is treated at the Livermore Water Reclamation Plant (LWRP). As part of the Livermore-Amador Valley Wastewater Management Program, the treated sanitary wastewater is transported out of the valley through a pipeline and discharged into San Francisco Bay. A small portion of this treated wastewater is used for summer irrigation of the adjacent municipal golf course. Sludge from the treatment process is disposed of in sanitary landfills.

LLNL receives water from two suppliers. LLNL's primary water source is the Hetch-Hetchy Aqueduct. Secondary or emergency water deliveries are taken from the Alameda County Flood Control and Water Conservation District Zone 7. This water is a mixture of ground water and water from the South Bay Aqueduct of the State Water Project. Water quality parameters for the two sources are obtained from the suppliers and are used to evaluate compliance with the discharge permit conditions that limit changes in water quality between receipt and discharge.

Preventive Measures

Administrative and engineering controls at the Livermore site are designed to prevent potentially contaminated wastewater from being discharged directly to the sanitary sewer. Waste generators receive training on proper waste handling. LLNL personnel review facility procedures and inspect processes for inappropriate discharges. Retention tanks collect wastewater from processes that might release contaminants in quantities sufficient to disrupt operations at the LWRP; in 1998, there were approximately 40 retention tank systems in use at the Livermore Site. Wastewater that cannot be discharged into one or more of surface water collection units at LLNL's Remote Test Facility is transported to LLNL's Livermore site and managed under Livermore site retention tank administrative controls. Ground water generated from startup operations associated with new, portable ground water treatment units; tests of experimental treatment units, and maintenance of existing treatment facilities is analyzed for pollutants of concern and must meet permitted criteria, or LWRP approval must be obtained before it can be discharged to the sanitary sewer. Finally, to verify the success of training and control equipment, wastewater is sampled and analyzed not only at the significant points of generation, as defined by type and quantity of contaminant generated, but also at the point of discharge to the municipal sewer system.

For facilities with installed retention tank systems, collected wastewater is discharged to the sanitary sewer only if analytical laboratory results show that pollutant levels are within allowable limits (Grandfield 1989). LLNL developed internal discharge guidelines for specific sources and operations to ensure that sewer effluent for the entire site complies with LLNL's waste discharge permit. If pollutant levels exceed permissible concentrations, the wastewater is treated to reduce pollutants to the lowest levels practical and below LLNL guidelines, or it is shipped to an off-site treatment or disposal facility. Liquids containing radioactivity are handled on site and may be treated using processes that reduce the activity to levels well below those required by DOE Order 5400.5. Internal guidelines for retention tank systems and specific sources and operations are discussed later in the Categorical Discharges section. Process wastewater generation and discharge frequency from retention tanks vary from monthly to yearly depending upon the process. During 1998, LLNL discharged an average of 23 wastewater retention tanks each month, with an average volume of approximately 10,300 liters per tank.

For the year as a whole, the monitoring data reflect the success of LLNL's discharge control program in preventing any significant impact on the operations of Livermore's treatment plant and are generally consistent with past values.

Monitoring

Monitoring at the Sewer Monitoring Station

LLNL's sanitary sewer discharge permit requires continuous monitoring of the effluent flow rate and pH. Samplers collect flow-proportional composite samples and instantaneous grab samples that are analyzed for metals, radioactivity, toxic chemicals, and water-quality parameters. In addition, as a best management practice, the outflow to the municipal collection system is sampled continuously and analyzed in real time for conditions that might upset the LWRP treatment process or otherwise impact the public welfare. The effluent is continuously analyzed for pH, selected metals, and radioactivity. If concentrations above warning levels are detected, an alarm is registered at the LLNL Fire Dispatcher's Station, which is attended 24 hours a day, and the site effluent is diverted to the Sewer Diversion Facility (SDF), discussed in the Diversion System section. The monitoring system provides a continuous check on sewage control, and the LWRP is notified of contaminant alarms. Trained staff respond to all alarms to evaluate the cause and take appropriate action.

Monitoring at the Upstream pH Monitoring Station

During 1998, LLNL designed and built the pH Monitoring Station (pHMS) in response to Notices of Violations for 1996 and 1997 pH excursions that exceeded the permitted range. This project was completed and became operational in October 1998 (see **Figure 6-1** for a system diagram). The station continuously monitors pH between 7 a.m. and 7 p.m. during the work week and will divert pH discharges outside the permitted 5 to 10 range to the SDF. Generally, the pHMS duplicates the pH monitoring and diversion capabilities of the main Sewer Monitoring Station (SMS), but because it is located upstream of the SDF it is able to initiate diversion earlier. Earlier detection allows LLNL to divert all of the unpermitted site effluent, whereas, previously some effluent was released because of the physical locations of the SMS and the SDF. Although the 1996 and 1997 releases of the first few minutes of pH excursions had no impact on the LWRP treatment process or public welfare, they were, nonetheless, releases exceeding the permitted range, for which the LWRP issued Notices of Violation. Ultimately, as a best management practice, the pHMS supplements the SMS continuous monitoring system.

The upstream station is located in the northwest corner of the LLNL site where the two main trunk lines, running from east to west and south to north converge. This is also where the site effluent is monitored in the SMS shortly before discharge to the Livermore City sanitary sewer system (see **Figure 6-1**). In each of the main trunk lines, just prior to their point of convergence, manholes were installed with stainless steel channels for wastewater flow and grinders to homogenize the solid materials in

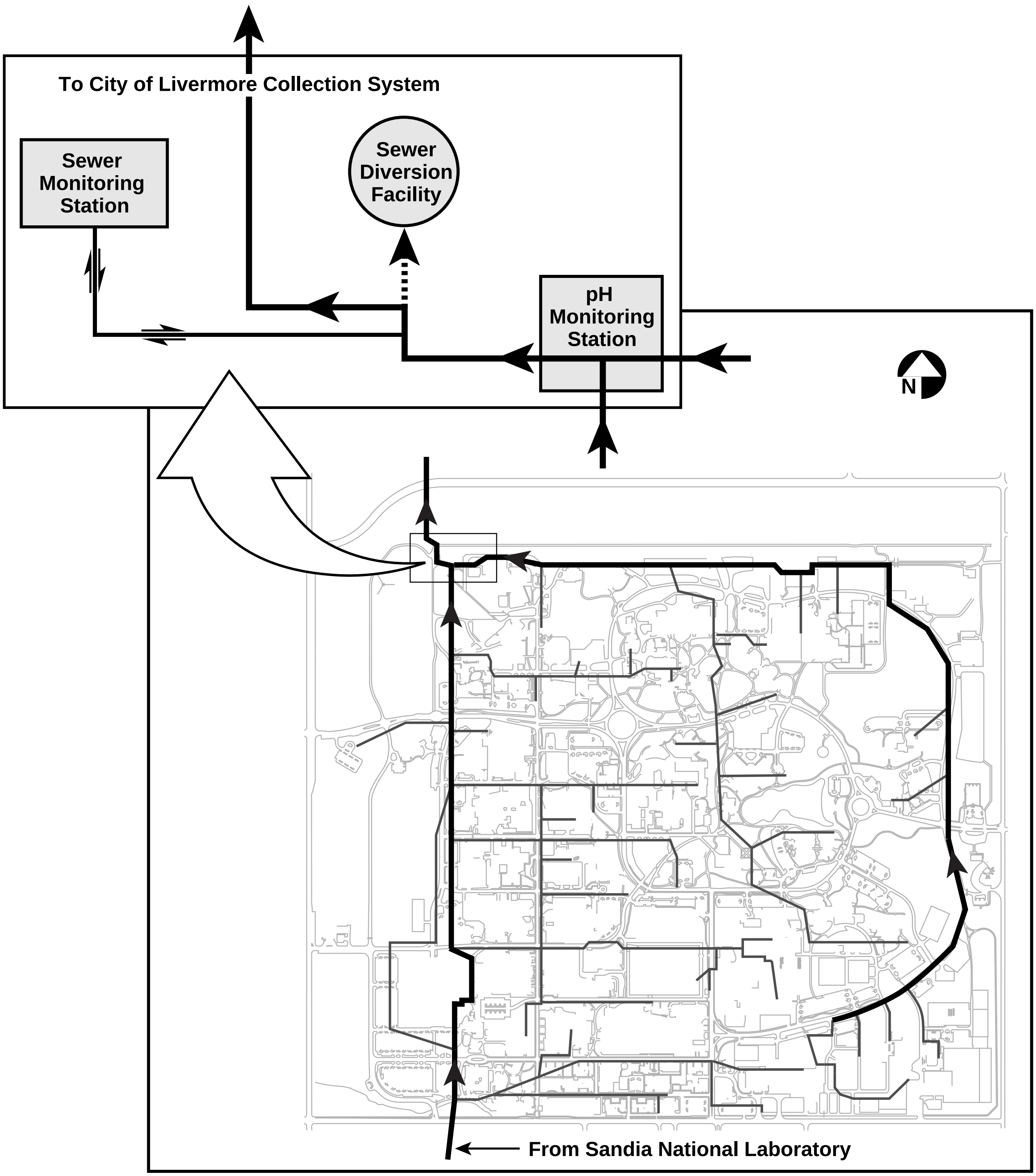

Figure 6-1. LLNL sanitary sewer system monitoring stations and diversion facility.

the flow. At the convergence, an underground vault was installed with a stainless steel channel to convey flow and stainless steel tubes angled into the flow stream to serve as conduits for monitoring probe insertion. The flow pH is monitored continuously at the point of convergence, as well as the in each of the main trunk lines (providing some measure of spill-traceback capability and confirmation of properly operating monitoring equipment). To measure flow rate in the combined stream, a Parshall flume and a sonic sensor head were also installed; flow-monitoring probes measure flow rate in each of the two main trunk lines entering the vault. The flow-rate data are transmitted to the nearby monitoring building, constructed to house a data logger and three samplers, which, activated by pH events, collects samples from the combined effluent and each of the two main trunk lines.

Diversion System

LLNL operates and maintains a diversion system that activates automatically when either the SMS continuous monitoring system or the pHMS sounds an alarm. The SDF ensures that all but the first few minutes of the potentially affected wastewater flow is retained at LLNL, thereby protecting the LWRP and minimizing any required cleanup. During pH excursions even the first few minutes of affected wastewater flow is retained, as described in the previous section. Up to 775,000 L of potentially contaminated sewage can be held pending analysis to determine the appropriate handling method. The diverted effluent may be returned to the sanitary sewer (if it meets LLNL's wastewater discharge permit limits), shipped for off-site disposal, or treated at LLNL's Hazardous Waste Management Facility. All diverted sewage in 1998 was returned to the sanitary sewer.

Pretreatment Discharges

The general pretreatment regulations establish both general and specific standards for the discharge of prohibited substances (40 CFR 403.5) that apply to all industrial users. These regulations apply even if LLNL is subject to other federal, state, or local pretreatment standards. The pretreatment standards contain prohibitions that are intended to protect the LWRP and its operations from interference with its treatment processes or pass-through that would cause the LWRP to violate its own effluent limitations. The LWRP, under the authorization of the SFRWQCB, requires self-monitored pretreatment programs at both the Livermore site and Site 300. The sampling and monitoring of nondomestic, industrial sources covered by pretreatment standards defined in 40 CFR 403 is required in the 1998–1999 Wastewater Discharge Permit (No. 1250) issued for the discharge of wastewater from LLNL into the City of Livermore sewer system. Permit 1250 lists all the self-monitoring parameters that are applied at the SMS before wastewater enters the municipal collection system (see **Figure 6-1**). Those parameters with numerical limits are listed in **Table 6-1**. Other required parameters such as flow rate, biological oxygen demand, total dissolved solids, total suspended solids, and tributyltin are also monitored at the SMS but have no specific numerical limits.

Table 6-1. Limits under Permit 1250 for discharges into the municipal sewer.

Constituent	Discharge limit
Metals (mg/L)	
Arsenic	0.06
Cadmium	0.14
Copper	1.0
Chromium (total)	0.62
Lead	0.20
Mercury	0.01
Nickel	0.61
Silver	0.20
Zinc	3.00
Cyanide (mg/L)	0.04
Total Toxic Organics (mg/L)	1.00
pH (pH units)	5–10

Categorical Discharges

The Environmental Protection Agency (EPA) publishes categorical standards as regulations separate from the general pretreatment regulations and developed for broad categories of specific industrial processes determined to be the most significant contributors to point source water pollution. These standards contain specific numerical limits for the discharge of industry-specific pollutants from individual processes. The number of processes at LLNL utilizing these pollutants is subject to rapid and frequent change as programmatic requirements dictate. During 1998, the LWRP identified 20 specific LLNL wastewater generating processes that fall under the definition of two categorical standards: Electrical and Electronic Components (40 CFR 469), and Metal Finishing (40 CFR 433). The discharge limits for these standards are shown in **Table 6-2**. Under the terms in the permit, only those processes that discharge to the sanitary sewer require sampling, inspection, and reporting. Three of the 20 identified processes meet these criteria. In 1998, LLNL analyzed samples for all regulated parameters from these three processes and the results showed that LLNL complies with all federal categorical discharge limits.

Table 6-2. Discharge limits for nonradioactive pollutants in wastewaters at point of discharge into LLNL sewer.

Parameter	Discharge limit			
	Internal[a]	Metal finishing[b]	Electric component[b]	Permit 1510G
Metals (mg/L)				
Arsenic	NA[c]	—[d]	0.83	0.06
Cadmium	0.9	0.07	—[d]	0.14
Chromium (total)	4.9	1.71	—[d]	0.62
Copper	10	2.07	—[d]	1.00
Lead	4.9	0.43	—[d]	0.20
Mercury	0.05	—[d]	—[d]	0.01
Nickel	5	2.38	—[d]	0.61
Silver	1	0.24	—[d]	0.20
Zinc	15	1.48	—[d]	3.00
Organics (mg/L)				
TTO[e]	4.57	2.13	1.37	1.00
Other (mg/L)				
Cyanide[f]	5	0.65	—[d]	0.04[g]
pH (pH units)	5–10	5–10	5–10	5–10

Note: Permit 1510G is discussed in the following section, Discharges of Treated Ground Water.

a These standards were established to meet the City of Livermore's requirements at the point of discharge to the Municipal Sewer (SMS).

b These standards were specified by EPA. By regulation, the EPA or City of Livermore limit is used, whichever is lower. Internal limits apply where no other standard is specified.

c NA = Not applicable. There is no specific internal discharge limit; therefore, the discharge limit in Permit 1250 is used as a guideline for this parameter.

d There is no specific categorical limit for this parameter; therefore, internal discharge limits apply.

e Total toxic organics, as defined by the Livermore Municipal Code.

f Limits apply to cyanide discharges other than cyanide salts. Cyanide salts are classified by the State of California as "extremely hazardous waste" and cannot be discharged to the sewer.

g Although Permit 1510G lists a discharge limit for cyanide, sample collection is not required by the self monitoring program.

The first of the three categorical processes that discharge directly into the sanitary sewer system is an abrasive jet machine (or water-jet) that is regulated under the Metal-finishing Point Source Category. The water-jet uses about 4–6 liters (1–1.5 gallons) of water per minute and is in use from four to six hours per day. Approximately 75 liters (20 gallons) per cycle of the filtered water are discharged to the sanitary sewer. The remaining water is pumped back into the water-jet for reuse.

The other two discharging categorical processes are both regulated under the Federal Electrical and Electronic Component Point Source Category. One is a series of processes clustered within a single building housing research-scale microfabrication laboratories used for developing prototype semiconductor devices. These laboratories discharge into a building wastewater retention system, and because they are housed within the same building, with no diluting flow, they share a single point of compliance. The second activity is a small gallium arsenide cutting operation; this process discharges directly to the sanitary sewer.

The non discharging processes, all regulated under the Metal-Finishing Point Source Category (40 CFR 433), are printed circuit board manufacture, electrolysis plating, chemical etching, electroplating, anodizing, coating, painting, cleaning, electrical discharge machining, irridite process, and abrasive jet machining (water-jet). The wastewater from these processes is contained for removal and appropriate disposal by LLNL's Hazardous Waste Management Division (HWM).

Tables 6-2 and **6-3** show LLNL's internal discharge limits for wastewater discharged to the sanitary sewer. Those processes that discharge to the sanitary sewer are subject to the pretreatment self-monitoring program specified in the Wastewater Discharge Permit issued by the LWRP. In 1998, no exceedances of the pollutant limitations in the discharge permit were observed.

Table 6-3. LLNL's internal discharge limits for radioisotopes in wastewaters. There is no gross gamma limit; isotope-specific limits apply.

Parameter	Individual discharge	Total daily limit for site
Gross alpha	11.1 Bq/L (300 pCi/L)	185 kBq (5.0 µCi)
Gross beta	111 Bq/L (3000 pCi/L)	1.85 MBq (50.0 µCi)
Tritium	185 kBq/L (5.0 µCi/L)	3.7 GBq (100.0 mCi)

Discharges of Treated Ground Water

LLNL's ground water discharge permit (1510G, 1998) allows treated ground water from site-wide CERCLA cleanup activities to be discharged in the City of Livermore sanitary sewer in compliance with **Table 6-2** effluent limitations taken from the Livermore Municipal Code.

During 1998, the volume of ground water discharged to the sanitary sewer was approximately 62,100 liters**.** Water discharges during this period were related to start-up operations associated with new portable treatment units being built and installed throughout the site, testing of an experimental nitrate removal treatment system, and maintenance of existing ground water treatment facilities. Eleven separate discharges were sampled and discharged to the sewer during this period, all in compliance with self-monitoring permit provisions of Permit 1510G. Concentrations of regulated compounds were all below discharge limits. Complete monitoring data are presented in the Data Supplement, Chapter 6.

Radioactive Pollutants in Sewage

Monitoring Results

LLNL determines the total radioactivity released from tritium, alpha emitters, and beta emitters based either on the measured radioactivity in the effluent or on the limit of sensitivity, whichever is higher (see **Table 6-4**). The 1998 combined releases of tritium and alpha and beta sources were 10 GBq (0.27 Ci). The total is based on the results shown in **Table 6-4**; unlike the years prior to 1996, the total does not include a contribution from Sandia / California, which concluded all of its tritium research activities as of October 1994. The cleanup activities at their former tritium research laboratories were completed by October 1995. The annual mean concentration of tritium in LLNL sanitary sewer effluent was 0.029 Bq / mL (0.78 pCi / mL).

Table 6-4. Estimated total radioactivity in LLNL sanitary sewer effluent, 1998.

Radioactive emitter	Estimate based on effluent activity (GBq)[a]	Limit of sensitivity (GBq)
Tritium	10	3.9
Alpha sources	0.042	0.034
Beta sources	0.29	0.044

a 37 Gbq = 3.7×10^{10} Bq = 1 Ci.

The concentrations of ^{239}Pu, ^{137}Cs, and tritium measured in the sanitary sewer effluent from LLNL and LWRP are presented in **Table 6-5**. The tritium numbers are based on the flow-weighted average of the individual daily sample results for a given month. The plutonium and cesium numbers are the direct result of analysis of monthly composite samples of LLNL and LWRP effluent, and quarterly composites of LWRP sludge. At the bottom of the table, the total activity released is given by radioisotope. This was

Table 6-5. Tritium, cesium, and plutonium in sanitary sewer effluents, LLNL and LWRP, 1998.

Month	^{3}H (mBq/mL)[a]		^{137}Cs (μBq/mL)[a]		^{239}Pu (nBq/mL)[a]		^{239}Pu (mBq/dry g)[a]
	LLNL	LWRP	LLNL	LWRP	LLNL	LWRP	LWRP sludge[b]
Jan	3.8	–3.0	1.4 ± 0.7	<0.41	214 ± 45	1.35 ± 8.40	
Feb	31 ± 4	–2.7	1.6 ± 0.7	<0.38	307 ± 57	–5.40 ± 7.29	
Mar	32 ± 4	3.1	1.1 ± 0.7	<0.38	147 ± 43	5.4 ± 20.7	0.30 ± 0.06
Apr	3.9	–0.26	1.4 ± 0.8	<0.47	189 ± 41	0.35 ± 6.14	
May	37 ± 4	3.1	1.2 ± 0.5	0.47 ± 0.53	437 ± 66	1.60 ± 6.48	
Jun	21 ± 4	2.8	1.5 ± 0.7	<0.46	185 ± 43	56.2 ± 26.9	0.32 ± 0.05
Jul	3.5	–2.2	1.3 ± 0.6	<0.45	264 ± 49	16.3 ± 21.9	
Aug	9.5	–4.1	1.6 ± 0.4	<0.39	148 ± 44	–6.1 ± 11.7	
Sep	8.9	1.8	1.5 ± 0.7	<0.39	137 ± 30	2.18 ± 4.70	0.21 ± 0.03
Oct	26 ± 4	2.9	1.8 ± 0.8	<0.56	180 ± 65	5.07 ± 5.85	
Nov	31 ± 6	4.3	0.93 ± 0.13	<0.41	131 ± 34	–2.43 ± 8.70	
Dec	61 ± 5	3.6	0.85 ± 1.02	0.32 ± 0.63	314 ± 54	4.63 ± 7.96	0.20 ± 0.03
Median	**24**	**<2.8**	**1.4**	**<0.41**	**187**	**1.9**	**0.25**
IQR[c]	**24**	**—[d]**	**0.4**	**—[d]**	**126**	**5.5**	**0.10**
	pCi/mL[e]						**pCi/ dry g[e]**
Median	**0.64**	**<0.08**	**4.7×10^{-5}**	**$<1.1 \times 10^{-5}$**	**5.1×10^{-6}**	**5.1×10^{-8}**	**0.0069**
IQR[c]	**0.64**	**0.13**	**1.3×10^{-5}**	**—[d]**	**3.4×10^{-6}**	**1.5×10^{-7}**	**0.0026**
	Annual total discharges by radioisotope						
	^{3}H		**^{137}Cs**		**^{239}Pu**		**Total[f]**
Bq/y	**1.0×10^{10}**		**4.7×10^{5}**		**7.7×10^{4}**		**1.0×10^{10}**
Ci/y	**0.27**		**1.3×10^{-5}**		**2.1×10^{-6}**		**0.27**
	Fraction of limit[g]						
DOE	**7.8×10^{-5}**		**2.4×10^{-6}**		**6.0×10^{-7}**		**7.8×10^{-5}**
10 CFR 20	**0.054**		**3.7×10^{-6}**		**3.0×10^{-5}**		**—[h]**

Note: Radioactivities are reported as the measured concentration and either an uncertainty (±2σ counting error) or as being less than or equal to the detection limit. If the concentration is less than or equal to the uncertainty or the detection limit, the result is considered to be a nondetection. See Main Volume Chapter 14, Quality Assurance.

a Ranges are only listed for activities that are above the limit of sensitivity.

b Sludge from LWRP digesters is dried before analysis. The resulting data indicate the plutonium concentration of the sludge prepared by LWRP workers for disposal at the Vasco Road Landfill in Alameda County.

c IQR = Interquartile range.

d Because of the large number of nondetections, the interquartile range is omitted. See Chapter 14, Quality Assurance.

e 1 Ci = 3.7×10^{10} Bq.

f Does not include gross alpha and beta results shown in **Table 6-4**.

g Fraction of limit calculations are based on the annual total discharge for a given isotope and the corresponding monthly concentration-based limit (multiplied by the annual volume of Livermore site effluent) or, preferably the annual limit, if one exists.

h The fraction of the 10 CFR 20 limit is not presented because tritium discharges have an annual limit and cesium and plutonium discharges have monthly concentration-based limits. See the individual fractions for each of these radioisotopes.

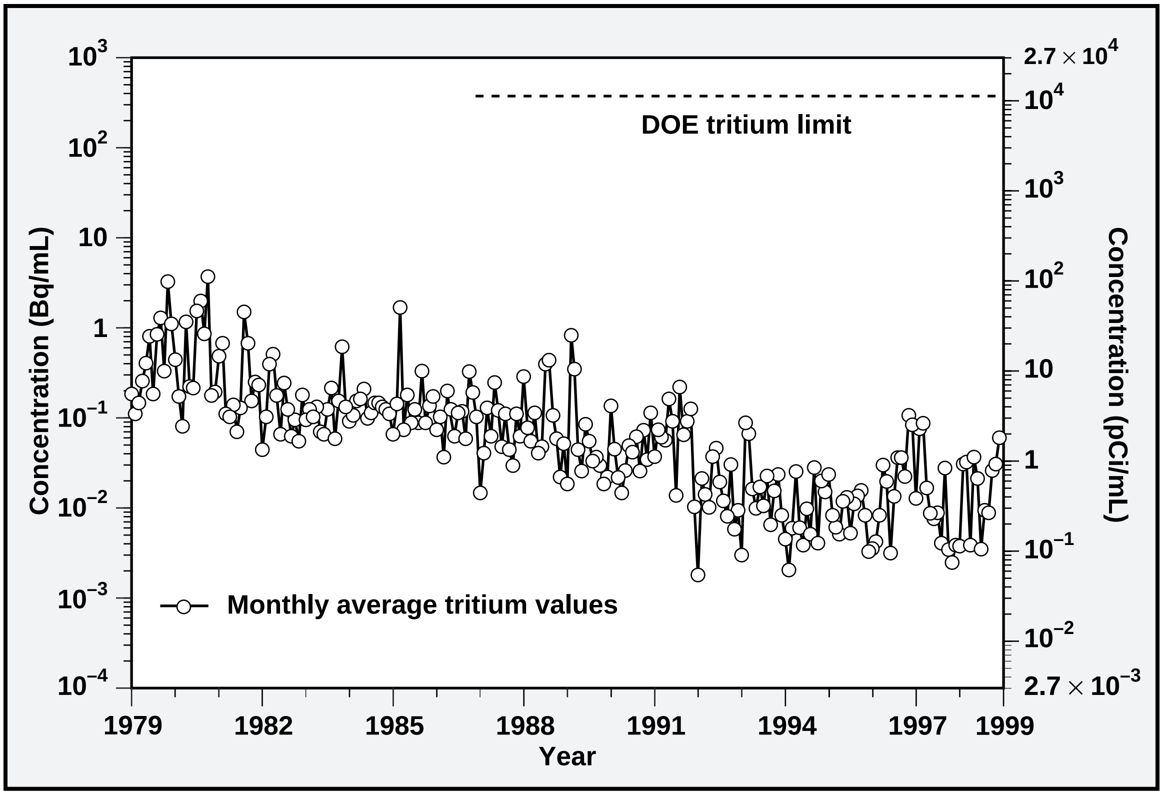

Figure 6-2. Historical trend in tritium concentration in LLNL sewage.

calculated by multiplying each sample result by the total flow volume over which the sample was collected, and summing up over all samples. The total activity released for each radioisotope is a conservative value; the limit of sensitivity was used in the calculation when the limit of sensitivity was greater than the actual activity reported. Also included in the table are fractions of DOE and 10 CFR 20 limits, discussed in the Environmental Impact section that follows.

The historical trend in the monthly average concentration of tritium is shown in **Figure 6-2**. Also included in the figure is the DOE tritium limit (370 Bq / mL), discussed in the Environmental Impact section of this chapter. The trend indicates a well-controlled tritium discharge, orders of magnitude below the DOE tritium limit.

Figure 6-3 shows the average monthly plutonium and cesium concentrations in sewage since 1989. The annual mean concentration of ^{137}Cs was 1.4 µBq / mL (3.8×10^{-5} pCi / mL); the annual mean ^{239}Pu concentration was 0.22 µBq / mL (5.9×10^{-6} pCi / mL).

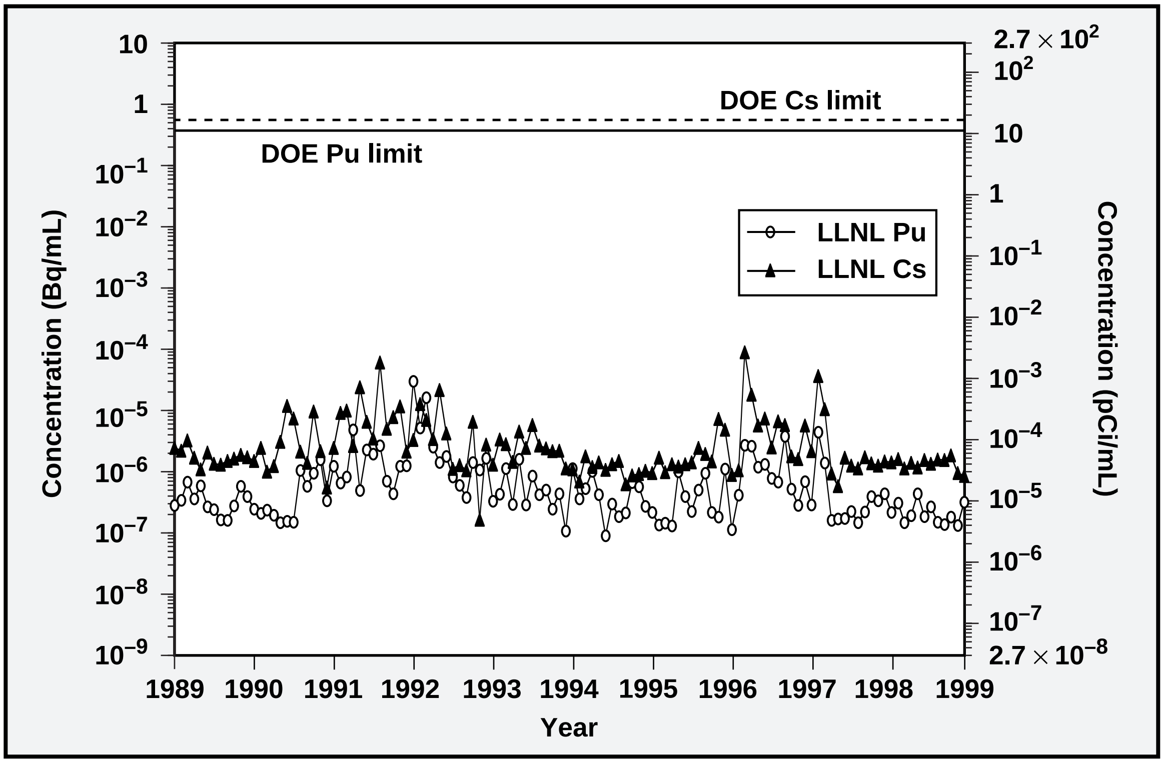

Figure 6-3. Historical trends in average monthly plutonium and cesium concentrations in LLNL sewage.

Environmental Impact

During 1998, no inadvertent releases exceeded any discharge limits for release of radioactive materials to the sanitary sewer system.

DOE Order 5400.5 established DOE policy requiring that radiological releases to the sanitary sewer comply with legally applicable local and state regulations and that LLNL implement standards generally consistent with those of the Nuclear Regulatory Commission. The most stringent of these limits was adopted in Title 17 of the California Code of Regulations. As a federal facility, LLNL is formally exempt from the requirements of state regulations but follows those requirements under the guidance of DOE. Title 17 contained a limit on discharges of radioactivity in sewage of 37 GBq (1 Ci) each year; it also listed limits on the daily, monthly, and annual concentration for each specific radionuclide.

In 1994, the discharge requirements previously found in Title 17 were removed, and the requirements in Title 10 of the Code of Federal Regulations, Part 20, were incorporated by reference. Title 10 contains a limit for the total discharge activity of tritium (185 GBq or 5 Ci), ^{14}C (37 GBq or 1 Ci), and all other radionuclides combined (37 GBq or 1 Ci); in addition, it specifies that the discharge material must be soluble and lists limits on monthly concentrations.

Table 6-6 summarizes the discharge requirements of Title 10. Because Title 10 permits and therefore applies to only soluble discharges, and because the plutonium in LLNL effluent is in both the soluble and insoluble forms, LLNL follows the discharge requirements for ^{239}Pu in DOE Order 5400.5, Radiation protection of the Public and Environment. This assumption is supported by our experience during the sewer system evaluation in the early nineties, when increased cleaning ware correlated with higher plutonium concentrations in LLNL sewage (Gallegos et al. 1992). This indicates that a portion of the plutonium discharges from LLNL facilities is deposited on the sewer pipes, and when these deposits are liberated and discharged from the LLNL site, they are, by their nature, insoluble.

Table 6-6. Sewer discharge release limits for ^{3}H, ^{137}Cs, and ^{239}Pu.

	^{3}H	^{137}Cs	^{239}Pu
10 CFR 20 concentrations used to establish release limits (Bq/mL)	370	0.37	0.0074
10 CFR 20 (GBq)			
Monthly	185[a]	11	0.21
Yearly	185[a]	37[b]	2.6
DOE annualized discharge limit for application of BAT[c] (Bq/mL)	370	0.56	0.37

a 10 CFR 20 imposes a 185-GBq (5-Ci) limit for the tritium radiation released.

b 10 CFR 20 imposes a 37-GBq (1-Ci) combined limit on the total of all radiation released (excluding tritium and ^{14}C, which have separate 10 CFR 20 limits of 185 GBq and 37 GBq, respectively); i.e., the total release of all isotopes must not exceed 37 GBq. If a total of 37 GBq of a particular isotope were released during the year, this would require that no other isotopes be released.

c BAT = best available technology. The DOE annualized discharge limit for application of BAT is five times the Derived Concentration Guide (DCG; ingested water) for each radionuclide released.

Table 6-6 also includes the total activity that could have been discharged by LLNL during a given period (monthly and annually) using 10 CFR 20 monthly concentrations in conjunction with the annual caps and assuming the 1998 average monthly flow rate and total flow volume. As the table shows, the Title 10 concentration limits for tritium for facilities such as LLNL that generate wastewater in large volumes are overridden by the limit on total tritium activity (185 GBq) dischargeable during a single year. In 1998, the total LLNL tritium release was 5.4% of the corresponding

Title 10 limit. Total LLNL releases (**Table 6-4**), in the form of alpha and beta emitters (excluding tritium), were 0.90% of the corresponding Title 10 limit.

DOE has also established criteria for the application of best available technology to protect public health adequately and minimize degradation of the environment. These criteria (the Derived Concentration Guides, or DCGs) limit the concentration of each specific radionuclide discharged to publicly owned treatment works. If a measurement of the monthly average concentration of a radioisotope exceeded its concentration limit, LLNL would be required to improve discharge control measures until concentrations were again below the DOE limits. **Table 6-6** presents the DCGs for the specific radioisotopes of most interest at LLNL.

The annual average concentration of tritium in LLNL sanitary sewer effluent was 7.8×10^{-5} (that is, 0.0078%) of the DOE DCG (and the Title 10 limit); the annual average concentration of ^{137}Cs was 2.4×10^{-6} (0.00024%) of the DOE DCG (and 3.7×10^{-6} or 0.00037% of the Title 10 limit); and the annual average ^{239}Pu concentration was 6.0×10^{-7} (0.000060%) of the ^{239}Pu DOE DCG, and 3.0×10^{-5} (0.0030%) of the Title 10 limit. These results are shown at the end of **Table 6-5**.

LLNL also compares annual discharges with historical values to evaluate the effectiveness of ongoing discharge control programs. **Table 6-7** summarizes the radioactivity in liquid effluent released over the past 10 years. During 1998, a total of 10 GBq (0.27 Ci) of tritium was discharged to the sanitary, an amount that is well within environmental protection standards and is comparable to the amounts reported for the last several years. Moreover, the total tritium released by LLNL in 1998 (and the years from 1992 through 1997) is below the range reported prior to 1992.

Figure 6-3 summarizes the ^{239}Pu monitoring data over the past 10 years. The historical levels observed since 1989 average 1 µBq / mL (3×10^{-5} pCi / mL). These historical levels generally are three-millionths (0.000003) of the DOE DCG for the ^{239}Pu. The greatest part of the plutonium discharged in LLNL effluent is ultimately concentrated in LWRP sludge, which is dried and disposed of at a landfill. The median plutonium concentration observed in 1998 sludge (**Table 6-5**), 0.25 mBq / dry g is approximately 370 times lower than the EPA preliminary remediation goal for residential soil (93 mBq / dry g) and is nearly 1500-times lower than the remediation goal for industrial or commercial soil (370 mBq / dry g).

Table 6-7. Radioactive liquid effluent releases from the Livermore site, 1989–1998.

Year	Liquid effluent (GBq)	
	^{3}H	^{239}Pu
1989	59	1.8×10^{-4}
1990[(a)]	25	2.3×10^{-4}
1991	32	6.1×10^{-4}
1992	8	1.9×10^{-3}
1993	13	2.6×10^{-4}
1994[(b)]	6.9	1.9×10^{-4}
1995	6.0	1.2×10^{-4}
1996	12[(c)]	4.2×10^{-4}
1997	9.1	2.1×10^{-4}
1998	10	7.7×10^{-5}

a The 1990 DOE Order 5400.5 required compliance with legally applicable local and state regulations. California Title 17 mandated a 37 GBq (1 Ci) combined limit on the total of all radiation released.

b In 1994, the discharge requirements previously found in Title 17 were changed to correspond to the requirements in Title 10 of the Code of Federal Regulations, Part 20. Title 10 contains a limit for the total discharge activity of tritium (185 GBq or 5 Ci), ^{14}C (37 GBq or 1 Ci), and all other radionuclides combined (37 GBq or 1 Ci).

c In 1995, Sandia National Laboratories/California (SNL/CA) ceased all tritium facility operations. Therefore, the annual tritium totals beginning with the 1996 value do not include contributions from Sandia/California.

As first discussed in the *Environmental Report 1991* (Gallegos et al. 1992), plutonium and cesium concentrations were slightly elevated during 1991 and 1992 over the lowest values seen historically. As was established in 1991, the overall upward trend was related to sewer cleaning with new, more-effective equipment. During 1993, as utility personnel worked to complete an assessment of the condition of the sewer system, cleaning activity around the site was less extensive, resulting in slightly lower plutonium and cesium concentrations in LLNL effluent. During 1994, in conjunction with the installation of the synthetic sock lining in the sewer system, the cleaning activity around the site was more extensive than in 1993. However, by the end of 1993 the new sewer cleaning equipment had been used on LLNL's entire sewer system; this was reflected in 1994 and the majority of 1995 by the continuation of the slightly lower plutonium and cesium concentrations that were observed in the 1993 effluent.

The plutonium and cesium concentrations in 1996 and the first quarter of 1997 are slightly higher than the concentrations observed in 1993 through 1995, and slightly lower than the observed concentrations of 1990 through 1992, with the exception of a cesium peak early in 1997. This peak, pictured in **Figure 6-3**, is attributable to a controlled release from an

LLNL retention tank system and is well below the applicable DOE DCG. The slightly higher plutonium and cesium concentrations of 1996 and the first quarter of 1997 are well below applicable DOE DCG's and remain indicative of well-controlled discharges. The final three quarters of 1997 and all of the 1998 plutonium and cesium concentrations are comparable to the concentrations observed in 1993 through 1995, and, as such, are also well below the applicable DOE DCGs.

Nonradioactive Pollutants in Sewage

Monitoring Results

Table 6-8 presents monthly average metal concentrations in LLNL's sanitary sewer effluent. The averages were obtained by a flow-proportional weighting of the results from analysis of the weekly composite samples collected each month. Each result was weighted by the total flow volume recorded by the SMS for the period during which the sample was collected. The results are generally typical of the values seen during previous years, 1994–1997, as discussed in the following section, Environmental Impact. **Figure 6-4** presents the average monthly results from 1994 through 1998 for eight metals. Weekly and 24-hour composite sample concentrations of metals in LLNL sewage are each presented as a percentage of the corresponding effluent pollutant limit (EPL) in **Figures 6-5a** and **6-5b**. The EPL is equal to the maximum pollutant concentration allowed per 24-hour composite sample, as specified by the LLNL wastewater discharge permit. When a weekly sample concentration is at or above 50% of its EPL, the corresponding daily (24-hour composite) samples collected in the SMS must be analyzed to determine if any of their concentrations are above the EPL.

Detections of anions, metals, and organic compounds and data concerning other physical and chemical characteristics of the sanitary sewer effluent are provided in **Table 6-9**. Although the samples were analyzed for bromide, nitrite (as N), carbonate alkalinity (as $CaCO_3$), hydroxide alkalinity (as $CaCO_3$), the full suite of polychlorinated biphenyls, the full suite of organochlorine pesticides, and cyanide, those analytes were not detected in any sample acquired during 1998, and so are not presented in the table. (Analysis of samples for polychlorinated biphenyls and organochlorine pesticides was discontinued in June 1998 after receiving a letter from the LWRP disallowing the need for these analyses.) The results are quite typical of those seen in previous years.

Table 6-8. Average monthly results for metals in LLNL sanitary sewer effluent (in mg/L), 1998.

Month	Parameter (mg/L)											
	Ag	Al	As	Be	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn
Jan	<0.010	0.59	0.0039	<0.00050	<0.0050	0.013	0.099	1.5	0.00054	0.0079	0.017	0.30
Feb	0.011	1.1	0.0057	<0.00050	0.010	0.024	0.17	2.6	0.00060	0.012	0.039	0.81
Mar	0.011	0.78	0.0035	<0.00050	<0.0050	0.031	0.16	2.4	0.00052	0.011	0.024	0.43
Apr	<0.010	0.29	0.0022	<0.00050	<0.0050	0.012	0.067	1.0	0.00031	0.0055	0.0052	0.21
May	<0.010	0.32	<0.0020	<0.00050	<0.0050	0.017	0.075	1.1	0.0027	0.0071	0.012	0.20
Jun	<0.010	0.27	0.0022	<0.00050	0.0056	0.015	0.082	0.9	0.00030	0.0066	0.0052	0.18
Jul	<0.010	0.33	0.0028	<0.00050	<0.0050	0.012	0.086	1.0	0.00023	0.0078	0.014	0.27
Aug	<0.010	0.25	<0.0020	<0.00050	<0.0050	<0.010	0.077	1.3	0.00038	0.0064	0.009	0.15
Sep	<0.010	0.31	0.0023	<0.00050	<0.0050	0.011	0.12	0.8	0.00023	0.0050	0.035	0.19
Oct	0.016	0.68	0.0026	<0.00050	<0.0050	0.026	0.15	1.9	0.00047	0.013	0.021	0.31
Nov	0.023	0.46	0.0026	<0.00050	<0.0050	0.019	0.087	1.3	0.00048	0.0090	0.016	0.20
Dec	<0.010	0.54	<0.0020	<0.00050	<0.0050	0.015	0.11	1.6	0.0021	0.015	0.022	0.26
Median	**<0.010**	**0.40**	**0.0025**	**<0.00050**	**<0.0050**	**0.015**	**0.093**	**1.3**	**0.00048**	**0.0079**	**0.017**	**0.24**
IQR[a]	**—[b]**	**0.3**	**0.0008**	**—[b]**	**—[b]**	**0.008**	**0.047**	**0.7**	**0.00025**	**0.0047**	**0.011**	**0.11**
EPL[c]	**0.2**	**—[d]**	**0.06**	**—[d]**	**0.14**	**0.62**	**1**	**—[d]**	**0.01**	**0.61**	**0.2**	**3.0**
Median percentage of EPL	**<0.05**	**—[d]**	**0.04**	**—[d]**	**<0.04**	**0.02**	**0.09**	**—[d]**	**0.05**	**0.01**	**0.08**	**0.08**

Note: Monthly values are presented with less than signs when all weekly composite sample results for the month are below the detectable concentration.

a IQR = Interquartile range.

b Because of the large number of nondetects, the interquatrile range cannot be calculated for these metals. See Chapter 14, Quality Assurance.

c Effluent pollutant limit (LLNL Waste water Discharge Permit 1997–1998 and 1998–1999).

d No established limit for this metal.

Environmental Impact

At the bottom of **Table 6-8**, the annual median concentration for each metal detected in LLNL's sanitary sewer effluent is compared to the discharge limit. In 1998, the ratio of the annual median concentration of each metal to its corresponding discharge limit was either the same as 1997, or lower. The metal that approached closest to the discharge limit was copper at 9.3%.

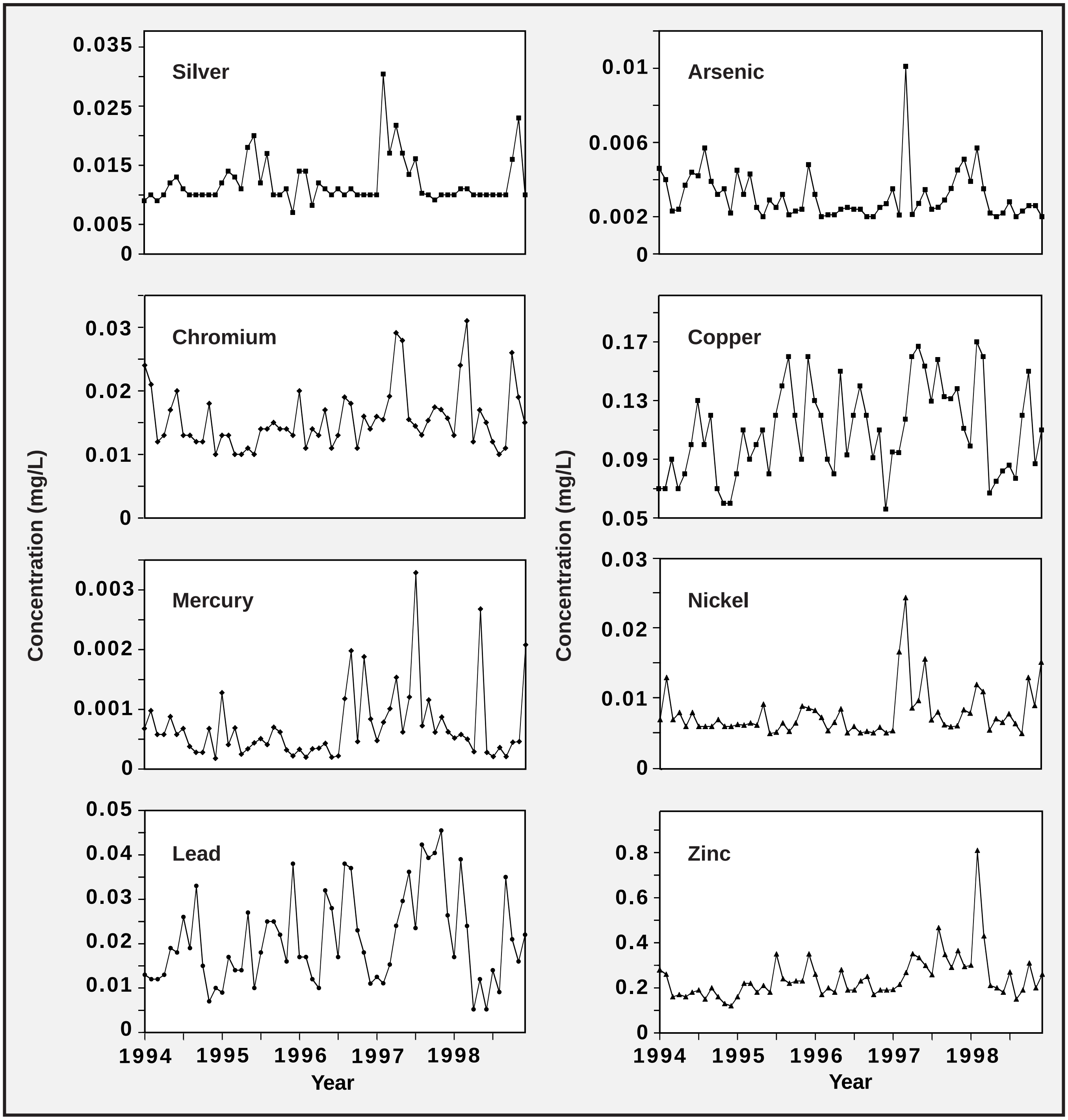

Figure 6-4. Average monthly concentrations of eight metals in LLNL sanitary sewer effluent showing trends from 1994 through 1998.

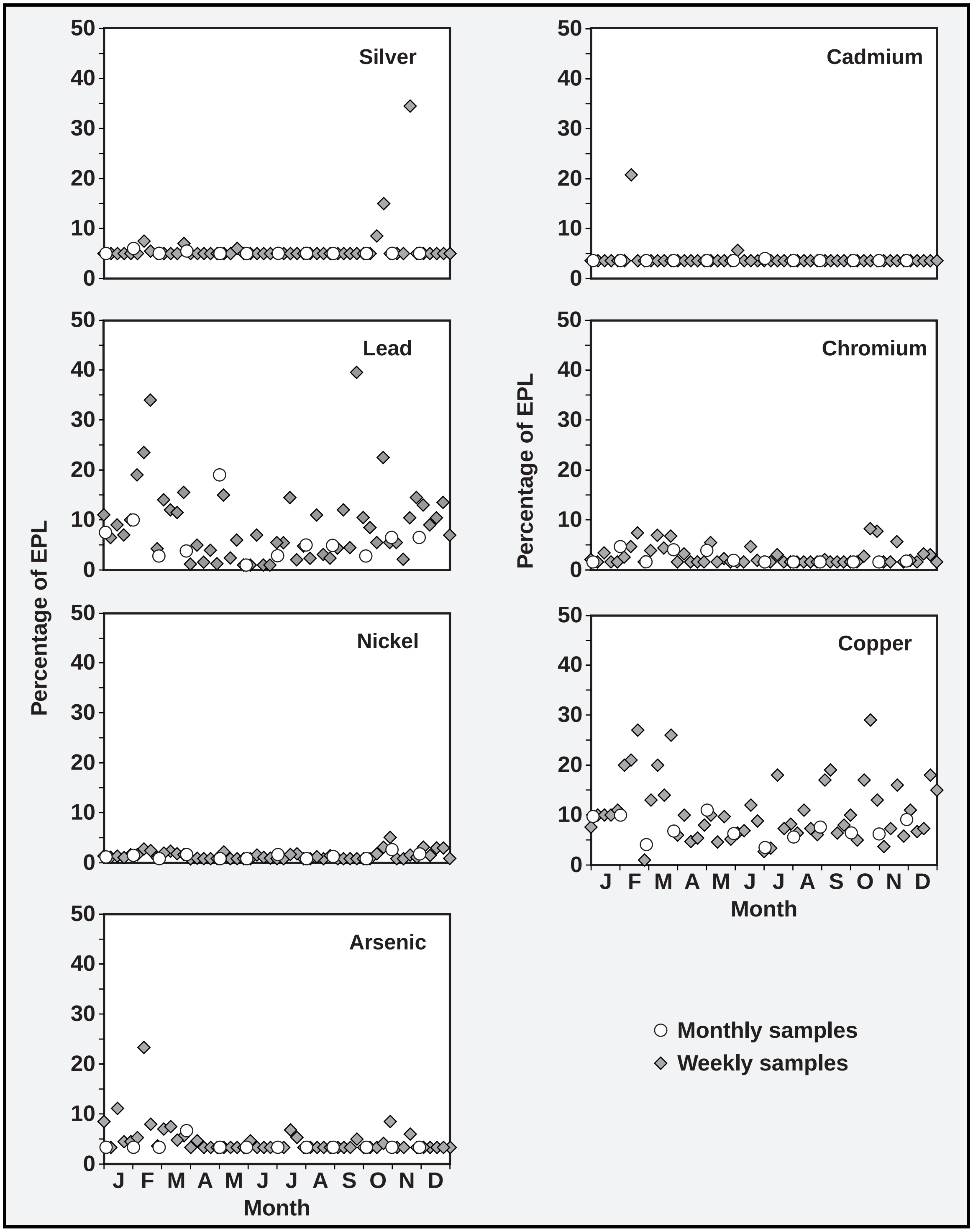

Figure 6-5a. Results as percentages of effluent pollutant limits (EPLs) for seven of the nine metals regulated in LLNL sewage.

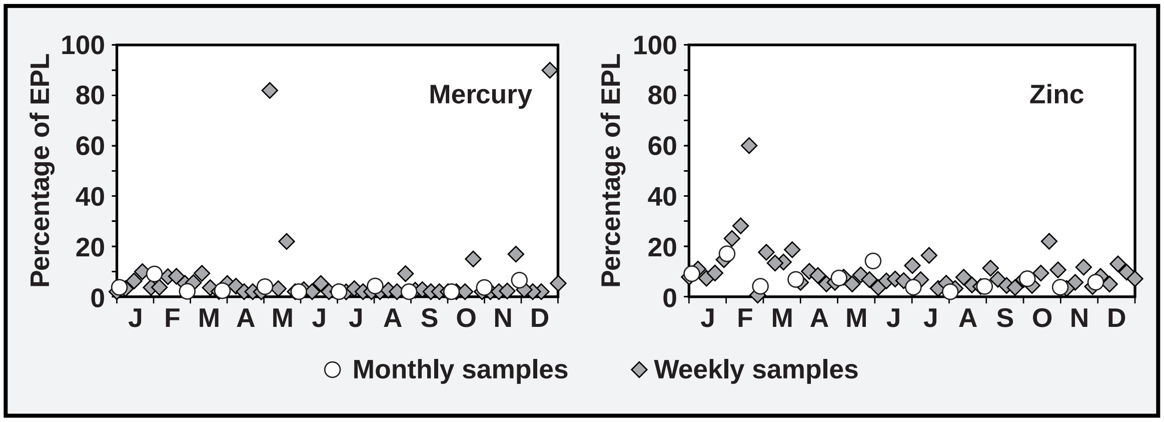

Figure 6-5b. Results as percentages of effluent pollutant limits (EPLs) for two of the nine metals regulated in LLNL sewage.

Although well below discharge limits, slightly elevated arsenic levels were seen in 1992 through 1995. These levels did not continue in 1996, but returned during the beginning of both 1997 and 1998. First discussed in the *Environmental Report 1993* (Gallegos et al. 1994), the elevated arsenic levels were the subject of an extended investigation during 1993, which concluded that the presence of arsenic in the sewer was associated with the ground water cleanup at the gas pad along the southern border of the site. The gas pad cleanup operation was continued in 1994, and the slightly elevated arsenic levels of 1993 continued in 1994. During 1995, the gas pad cleanup operations were reduced, and the elevated arsenic levels were seen less frequently. In 1996, the gas pad operations were concluded, and arsenic levels returned to pre-1992 concentrations. In 1997, gas pad operations were performed separately using portable treatment units, and the arsenic concentrations rose slightly. During 1998, groundwater clean-up activities were accelerated with the deployment of several new portable treatment units, and slightly elevated arsenic concentrations reflected this increased activity.

The 1998 monthly mercury values continued to reflect the slightly elevated trend that began in mid-1996. However, only two of the analytical results for mercury in 1998 exceeded the action level in LLNL's Wastewater Discharge Permit, which states that archived daily composite samples must be analyzed for the pollutant of concern when the result for a weekly composite sample is 50% of, or greater than, the applicable effluent pollutant limit. The first mercury analytical result (0.0082 mg/L) exceeding the action level (0.005 mg/L) occurred in May (see **Figure 6-5b**). The archived daily samples that corresponded to the appropriate weekly composite sampling period of May 5–11 were submitted for mercury analysis. All of the analytical results for the daily

Table 6-9. Monthly monitoring results for physical and chemical characteristics of the LLNL sanitary sewer effluent, 1998.[a]

24-hour composite sample parameter (mg/L)	Detection frequency[b]	Minimum	Maximum	Median	IQR[c]
Alkalinity					
Bicarbonate alkalinity (as $CaCO_3$)	12/12	180	240	200	25
Total alkalinity (as $CaCO_3$)	12/12	180	240	200	25
Anions					
Chloride	11/11	33	63	45	16
Fluoride	11/12	<0.050	0.42	0.095	0.044
Nitrate (as NO_3)	4/12	<0.50	1.7	<0.50	—
Orthophosphate	12/12	1.3	23	16	13
Sulfate	11/11	13	21	15	3.0
Nutrients					
Ammonia nitrogen (as N)	12/12	35	76	49	9.5
Total Kjeldahl nitrogen	12/12	26	65	47	14
Oxygen demand					
Biochemical oxygen demand	12/12	100	610	235	123
Chemical oxygen demand	12/12	140	680	290	153
Solids					
Solid settling rate (mL/L/h)	10/12	<0.50	62	25	18
Total dissolved solids	12/12	130	720	250	45
Total suspended solids	12/12	53	400	245	195
Volatile solids	12/12	55	380	230	125
Total metals					
Calcium	12/12	9.7	21	12	4.3
Magnesium	12/12	2.1	3.9	2.8	1.1
Potassium	12/12	14	21	18	2.5
Sodium	12/12	23	47	35	8.3
Total organic carbon	12/12	46	110	66	19
Tributyltin (ng/L)	12/12	15	160	30	32
Semivolatile organic compounds					
Benzyl Alcohol	2/12	<10	100	<10	—
Bis(2-ethylhexyl)phthalate	6/12	<5.0	50	8.5	—
Di-n-butylphthalate	1/12	<5.0	120	<5.0	—
Diethylphthalate	7/12	<5.0	50	9.2	5.9
m- and p- Cresol	2/12	<5.0	50	<5.0	—
Total oil and grease	12/12	18	26	21	1.8
Total recoverable phenolics	12/12	0.019	0.12	0.038	0.030

Table 6-9. Monthly monitoring results for physical and chemical characteristics of the LLNL sanitary sewer effluent, 1998 (concluded).[(a)]

24-hour composite sample parameter (mg/L)	Detection frequency[(b)]	Minimum	Maximum	Median	IQR[(c)]
Volatile organic compounds (ug/L)					
1,4-Dichlorobenzene	3/12	<1.0	4.3	<1.0	—
Acetone	12/12	91	290	170	48
Chloroform	12/12	7.5	21	9.6	4.0
Ethylbenzene	1/12	<1.0	13	<1.0	—
Freon 113	2/12	<1.0	7	<1.0	—
Styrene	1/12	<1.0	67	<1.0	—
Toluene	1/12	<1.0	1.3	<1.0	—
Trichlorofluoromethane	2/12	<1.0	1.4	<1.0	—

a The 24-hour composite sample results plotted in **Figures 6-5a** and **6-5b** and reported in the Data Supplement, Chapter 6 are not reported in this table.

b The number of times an analyte was positively identified, followed by the number of samples that were analyzed (generally 12, one sample for each month of the year).

c IQR = Interquartile range. Where the detection frequency is less than or equal to 50%, the interquartile range is omitted.

samples were less than the effluent pollutant limit of 0.01 mg/L. The other mercury analytical result (0.047 mg/L) exceeding the action level occurred in December (see **Figure 6-5b**). The archived daily samples for the weekly composite sampling period of December 22–28 were submitted for mercury analysis. All of the analytical results for the daily samples were less than the effluent pollutant limit of 0.01 mg/L.

In two single instances, once for zinc and once for arsenic, weekly metals concentrations exceeded the permit action level. In February, a zinc concentration of 1.8 mg/L (see **Figure 6-5b**) exceeded the 1.5 mg/L action level. The daily samples for the sampling period of February 16–23 were analyzed, and all of the results were below the effluent pollutant limit of 3.0 mg/L. Finally, the arsenic analytical result (0.037 mg/L) exceeding the action level (0.03 mg/L) occurred in December; this sample concentration is not reflected in the arsenic plot of **Figure 6-5a** because it is a quality assurance data result, and data shown in **Figures 6-5 a and 6-5b** are exclusively from primary, non-quality assurance analyses. The archived daily samples that corresponded to the appropriate weekly composite sampling period of December 22–28 were submitted for arsenic analysis, and all of the analytical results were less than the effluent pollutant limit of 0.06 mg/L.

In 1998, the continuous monitoring system detected two inadvertant discharges. Both discharges occurred on January 31 and contained elevated levels of zinc. Analysis of the January 31 daily sample gave a result of 1.0 mg/L, which was below the discharge limit of 3.0 mg/L and thus in compliance with the permit requirement. Unconfined pH, metals or radiation releases of sufficient concentration and duration outside of the effluent pollutant limits could disrupt treatment plant operations or cause the treated wastewater to exceed allowable concentration limits for discharge to the San Francisco Bay. (For comparison, 13, 1, 1, 1, 0, and 13 such diversions occurred in 1997, 1996, 1995, 1994, 1993, and 1992, respectively.)

Monitoring results for 1998 reflect an outstanding year for LLNL's sewerable water discharge control program and Livermore site personnel. LLNL achieved 100% compliance with the provisions of its wastewater discharge permit, and only two inadvertant discharges were detected by the continuous monitoring system.